NATIONAL AGENCY FOR ENTERPRISE AND HOUSING

Monitoring of Torzhkovskaya 16

St. Petersburg

Monitoring report

Februar 2004

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Photo No. 1:Torzhkovskaya 16 before renovation

1 SUMMARY

VELUX International A|S was leading a consortium of a.o. Danfoss A/S, Grundfos A/S and Rockwool A/S, which undertook the renovation of the dwelling house at Torzhkovskaya 16 in St. Petersburg. Construction of an attic comprising nine apartments was part of the project. The dwelling house was provided with external insulation, the windows were sealed, and thermostatic valves installed at the radiators. Carl Bro a|s was invited to monitor the changed energy consumption during a heating season.

Photo No. 2: Torzhkovskaya 16 after the renovation

The monitoring program revealed that the energy consumption for heating decreased to approximately 35-40% compared to a neighbouring block, Torzhkovskaya 14. The 60% energy saving was registered by the heat meter during the coldest day in the monitoring period. During the warmer days the differences between the two dwelling blocks reached 30%, giving almost 70% savings. This was due to the automatically control equipment, which avoided overheating of the apartments. The uncertainty of the results is due to the fact that the indoor temperatures in the renovated block were significantly higher than the reference block (2ºC), which in periods could hardly maintain 20ºC in the flats. When we adjust the registered energy consumptions in the two buildings with the difference in the indoor temperature, we assume that the resulting energy consumption is 33% of the reference house and the saving therefore is 67%.

The calculated change in the design heat demand was approximately 38% of the original.

The program also revealed that the operation of the district heating system was inefficient to keep steady indoor temperatures and that the existing old type installations were inadequate at the lower outdoor temperatures.

2 INTRODUCTION

The renovation of Torzhkovskaya 16 was undertaken from 1999 to 2000 by a consortium lead by the Danish company Velux International a|s. The renovation included construction of an attic with nine modern apartments. The basic building was given an external insulation, the windows were sealed and all radiators were equipped with thermostatic valves.

The Danish consultancy company Carl Bro a|s was invited to monitor the heat consumption and define the heat savings reached by the renovation.

The monitoring program was undertaken during two heating seasons from 2001 to 2003. The basic principle for the monitoring program was comparison of the renovated building with the neighbouring dwelling block, Torzhkovskaya 14. The two dwelling blocks were identical in size and function.

The monitoring program was scheduled for one season only, but due to a number of obstacles with the installation of the heat meters, the program was extended with the following winter.

In the summer 2002 the substation in Torzhkovskaya 14 was renovated and the already installed heat meter was lost. The heat meter was not found and installed until 5th December 2002. The complete monitoring program ran to May 2003.

3 THE MONITORING PROGRAMME

The monitoring programme was initiated in autumn 2001. The programme comprised the two main parts:

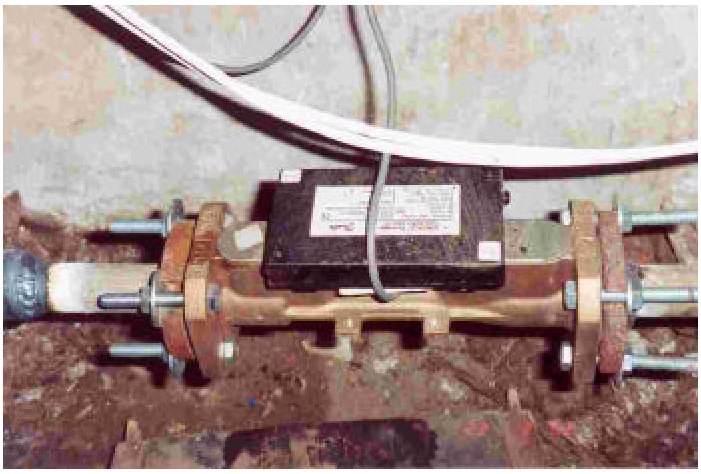
- Daily registration of heat consumption, flow and temperatures by the means of energy meters.
- Automatic hourly registration of temperatures by loggers placed various places in the buildings.

The monitoring focused on the following heating periods:

- 1st period is 20th December 2001 – 30th April 2002
- 2nd period is 20th September 2002 – 30th April 2003

Renovation of Torzhkovskaya, 16 was done to reduce the loss of heat from the building, but did not include renovation of the hot water supply for the entire building. Loggers have registered temperature for hot tap water all year round, but the evaluations of these results are only presented for the above-mentioned periods.

3.1 Daily registrations



Two meters were installed; one in Torzhkovskaya 14 and one in Torzhkovskaya 16. Both meters were placed on the main heat supply pipe for each building. These meters were read manually for heat and water flow on a daily basis along with the reading of primary supply and return temperature.

3.2 Data loggers

Twenty-five loggers were installed in the following places:

- In Torzhkovskaya 14 and 16 respectively, 4 loggers were placed in the basement. One logger on the primary supply pipe, the second on the primary return pipe, the third on the secondary supply pipe and the fourth on the hot water supply pipe.
- One logger was installed outside to register the outdoor temperature.
- Seven loggers were placed in various apartments in Torzhkovskaya 14.
- The remaining 9 loggers were installed in various apartments in Torzhkovskaya 16 including the new apartments in the attic.

Some loggers have had a malfunction in minor periods, but these data have been taken out before evaluation.

4 RESULTS

4.1 Degree days

From the registration of the outdoor temperature during the whole season we found that the season degree-days were about 4400, based on 20 ºC indoor temperature and excluding all days with an average temperature above 12ºC.

The evaluation of the results focused on two heating periods. These heating seasons were based on a calculation of degree days showing the following heating seasons: the first heating season to commence the 25th of December 2001 and end the 18th of April 2002 and the second heating season to commence the 21st of September and end the 5th of May 2003.

The total amount of degree days were:

- 1460 for the first period 25th December 2001 till 18th April 2002
- 3932 for the second period 21st September 2002 till 5th May 2003.

4.2 Registrations of heat consumption

The daily heat registrations showed that on the coldest day, -24°C in the second heating season, Torzhkovskaya 14 used 4833 kWh, while Torzhkovskaya 16 used 1910 kWh.
Looking at the warmest day of the same period Torzhkovskaya 14 used 2897 kWh and Torzhkovskaya 16 used 1000 kWh.
This calculation did not include the heat consumption used for the attic in Torzhkovskaya 16.

- The coldest day the consumption was 40% of the original
- The warmest day the consumption was 35% of the original.

When looking at the registration it is significant that the apartments were under heated during the coldest days and did not maintain 20 ºC indoor temperature. In order to calculate the design heat demand (capacity demand) we therefore added additional heat.

The capacity demand for heat for the two blocks were therefore:

- Torzhkovskaya 16: 100 kW (including 20% due to under heating)
- Torzhkovskaya 14: 260 kW (including 30% due to under heating)

The capacity demand was calculated by taking the daily consumption, divided by the hours and added an under heating factor due to the registered lower indoor temperature.
The theoretical difference between the two blocks was therefore a resulting heat demand of 38% compared to the original design.

Based on the registered heat consumption and the outdoor temperatures we calculated the entire heat demand for the season. The season heat consumption registered and adjusted by degree days were:

- Torzhkovskaya 16: 300 MWh
- Torzhkovskaya 14: 760 MWh

which gave an annual reduction of 39% and energy saving of 61%

The area of both buildings was 3349 m^2, which gave the following key figures for the blocks:

- Torzhkovskaya 16: 90 kWh / m^2
- Torzhkovskaya 14: 228 kWh / m^2

Compared to Danish conditions a normal older dwelling block has an energy consumption 90-150 kWh / m^2 based on 2900 degree days (which is 65% of St. Petersburg degree days). On the other hand the indoor temperatures in Denmark are normally a little higher than in St. Petersburg.

Figure 4.1 shows the daily heat consumption for Torzhkovskaya 14 and 16 sorted on the average outdoor temperature.

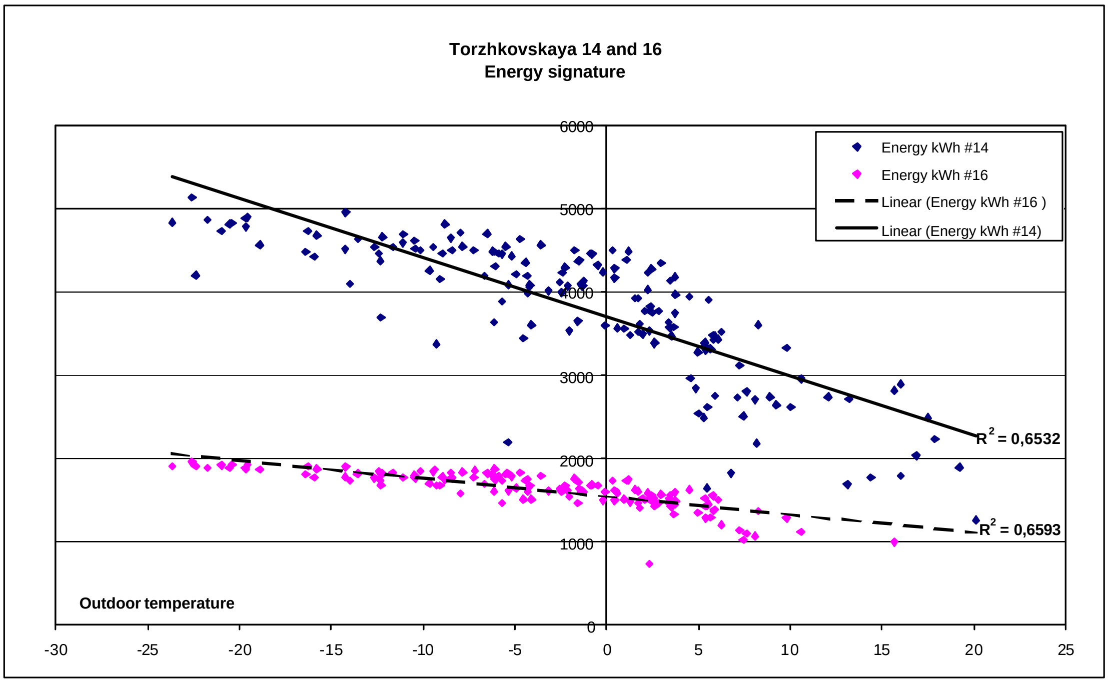


Figure 4.1. Heat consumption for Torzhkovskaya 14 and 16 sorted on outdoor temperature.

It can be seen that the heat consumption is significantly lower in the renovated building. Furthermore, the graph shows that the measured heat consumption in Torzhkovskaya 16 is closer to the average heat consumption compared to the measurements made in Torzhkovskaya 14.
The conclusion is that the heat consumption has been reduced and stabilised as a result of the renovation of the building. The heat consumption in Torzhkovskaya 16 relates nicely to the outdoor temperature.

4.3 Registration of flow

When registering the heat consumption, we also registered the flow. The relation between heat and flow is as follows:

Heat [kcal/h] = Flow [m3/h] * Difference in temperature [oC]

The flow therefore indicates how well the system is operating.

Figure 4.3 and 4.4 below indicates the flow during the season in Torzhkovskaya 14 and 16 respectively.

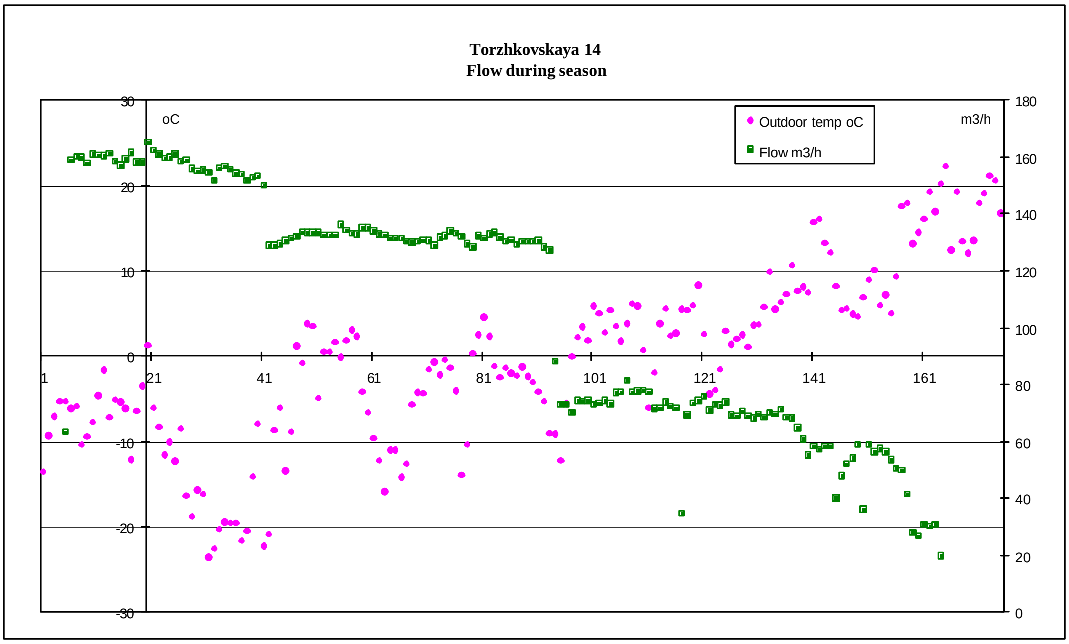


Figure 4.2. Flow and outdoor temperature during the season for Torzhkovskaya 14.

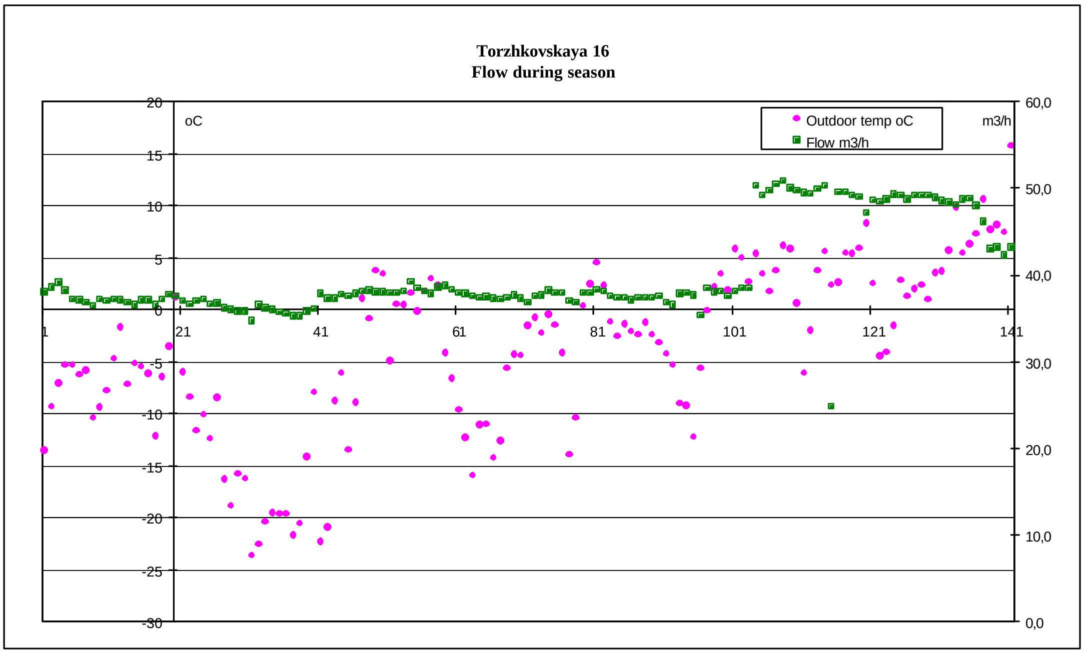


Figure 4.3. Flow and outdoor temperature during the season for Torzhkovskaya 16.

The graphs show that the flow for Torzhkovskaya 14 varies almost dependent on the outdoor temperature. The flow in Torzhkovskaya 16 is stable independent of the outdoor temperature. In conclusion, the constant flow in Torzhkovskaya 16 is an indication of a better functioning system than the system in Torzhkovskaya 14. The heating system in Torzhkovskaya 14 is the originally designed system with hydro-elevator, which assumes constant flow. The heat control is done through temperature control. However, this condition is not met in reality.

4.4 Heat cooling temperatures

Readings of primary supply and return temperatures were carried out in coordination with meter readings. The temperature readings showed an average cooling during the season in:

- Torzhkovskaya 14 of 25,4ºC.
- Torzhkovskaya 16 of 35,7ºC.

Both of these cooling temperatures were rather good and the higher the cooling of the water, the better the system. The insulation of the house and installation of thermostatic valves resulted in a 29% improvement of the cooling, which was mostly of benefit to the district heating supplier.

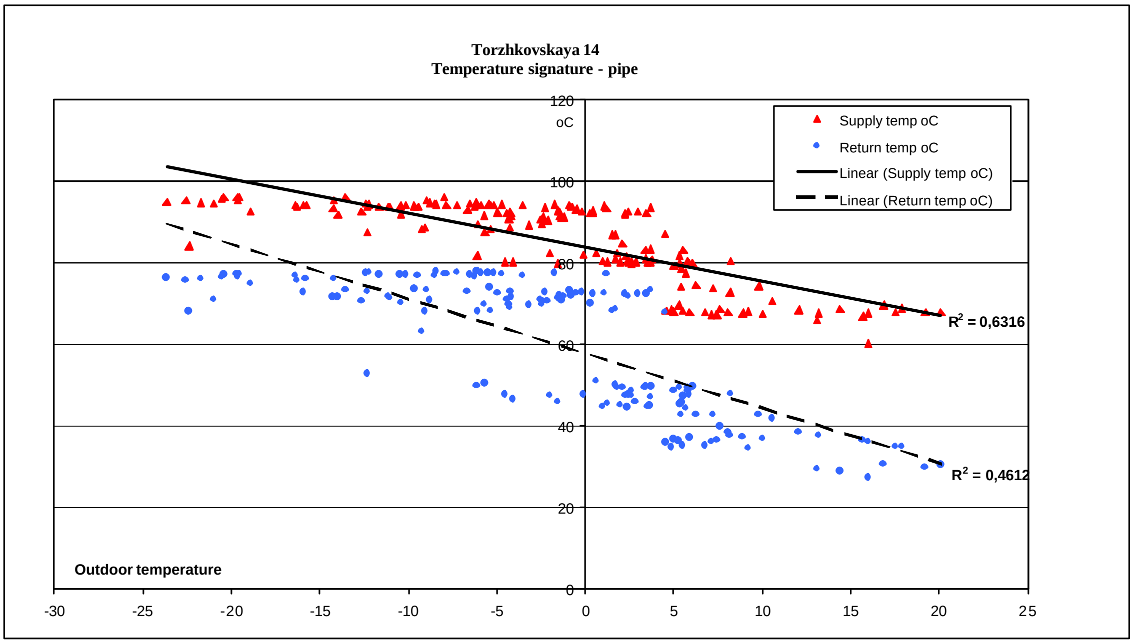


Figure 4.4. Primary supply and return temperatures for Torzhkovskaya 14 sorted on outdoor temperature.

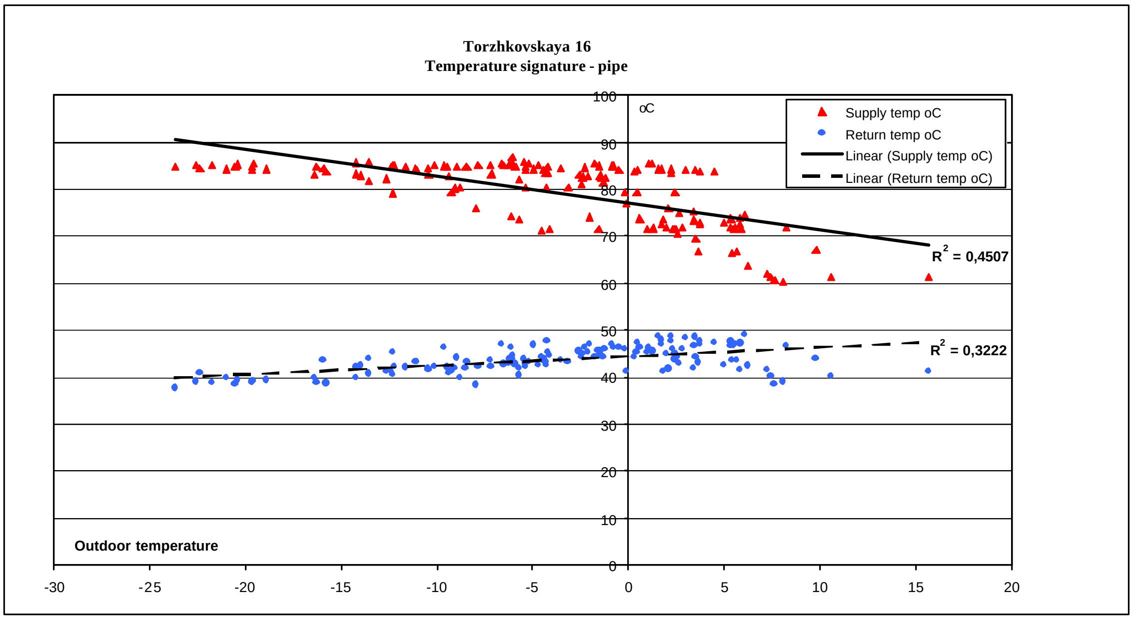


Figure 4.5. Primary supply and return temperatures for Torzhkovskaya 16 sorted on outdoor temperature.

It is significant that the supply temperatures were very stable during the whole season from –25ºC to +5ºC. Knowing that the internal heating system in both blocks functions with hydro elevators, this cannot be according to the presumed situation for the operation. The data also revealed poor operating capacity, especially for Torzhkovskaya 14 and insufficient heat supply on the coldest days.

While the cooling temperature decreased for Torzhkovskaya 14 with lower outdoor temperatures, it increased for Torzhkovskaya 16. The fact that the cooling increased with a lower outdoor temperature is not necessarily an implication of a well functioning system. Comparing the temperature signatures above with the flow signature shown in the Appendix, it can be seen how a stable and low flow influences on the cooling temperature. By low outdoor temperatures Torzhkovskaya 14 had a high flow and the hot water circulated through the system without delivering much heat to the building, which was reflected in the low cooling temperature. InTorzhkovskaya16 the system was well functioning with a low and stable flow and a high cooling temperature. However, we also noticed that the temperatures in most of the apartments had a tendency of dropping at low outdoor temperatures. The conclusion is that we have a well functioning system, but the supply temperature at low outdoor temperatures is too low.

4.5 Temperature registration

Data loggers registered the temperatures outside, in a number of apartments and at the main pipes in the buildings during two heating seasons. The results are shown in the Appendix with graphs showing registrations from Torzhkovskaya 16 and Torzhkovskaya, 14 respectively.

4.5.1 Results from loggers placed in apartments

The room temperatures for the renovated building have increased compared to Torzhkovskaya 14, which is shown in the box below.

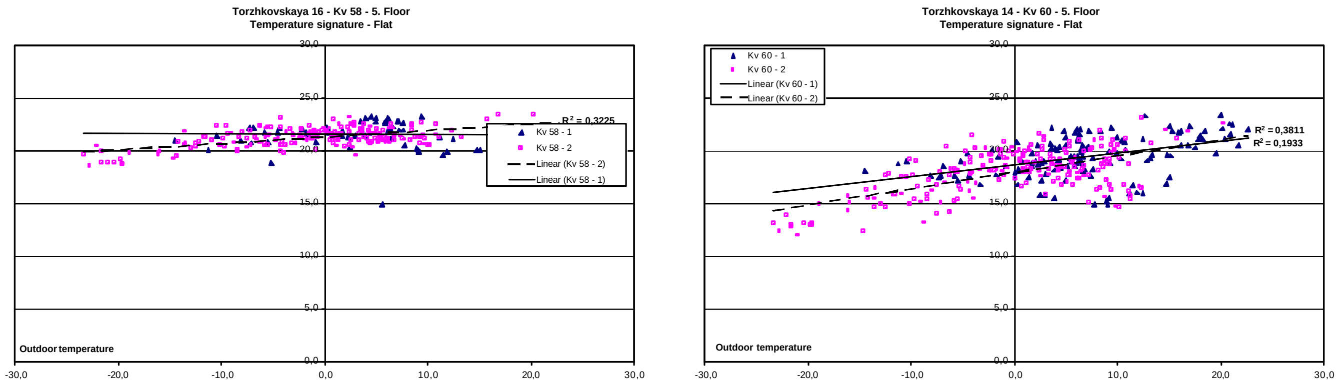
Floor	Average indoor temperature Torzhkovskaya 16	Average indoor temperature Torzhkovskaya 14	m^2, 16	m^2, 14	Temperature/ m^2 Torzhkovskaya 16	Temperature/ m^2 Torzhkovskaya 14
1.	Kv 22 – 20,4 °C	Kv 24 – 21,3 °C	31,0	31,0	0,66 °C/m^2	0,69 °C/m^2
	Kv 1 – 18,4 °C	-	17,5	-	1,05 °C/m^2	
2.	Kv 27 – 22,2 °C	Kv 7 – 18,1 °C	41,2	31,0	0,54 °C/m^2	0,58 °C/m^2
	Kv 48 – 23,0 °C	Kv 25 – 21,3 °C	17,5	31,0	1,31 °C/m^2	0,69 °C/m^2
3.	Kv 29 – 23,4 °C	-	31,0	-	0,75 °C/m^2	
4.	-	Kv 14 – 21,8 °C	-	27,9		0,78 °C/m^2
	-	Kv 53 – 18,3 °C	-	31,0		0,59 °C/m^2
5.	Kv 17 – 22,7 °C	Kv 17 – 17,1 °C	17,5	17,5	1,30 °C/m^2	0,98 °C/m^2
	Kv 58 – 21,4 °C	Kv 60 – 18,7 °C	31,0	17,5	0,69 °C/m^2	1,07 °C/m^2
Average	21,6 °C	19,5 °C			0,90 °C/m^2	0,77 °C/m^2

Table 4.1 Temperature difference in the apartment of Torzhkovskaya 14 and 16 respectively.

The table shows the average indoor temperatures in the apartments and the related square meters. Even though the difference between the two blocks are only 2 ºC in average over the whole season, it can be seen that when adjusted to the size of the apartments, the difference in indoor comfort is much more significant.

The apartments in the attic were not used and they were heated by electricity up to about 10 ºC during the whole season. In the evaluation we presumed the situation with the attic to be similar to the external insulation. The apartments at the 5th floor were as well heated as apartments at other floors. Once the attic will be occupied and heated, the situation for the rest of the building will be even better.

In the reference block Torzhkovskaya 14, we see significantly lower indoor temperatures on the top floor than in the rest of the building.



Graphs from the apartment temperature registration at the 5th floor in the two blocks; Torzhkovskaya 16 to the left and Torzhkovskaya 14 to the right.

When looking at the graphs it is significant that at low outdoor temperatures it is not possible to maintain a comfortable indoor temperature above 20 ºC in neither of the buildings. This is due to the fact that the primary supply temperature does not follow the outdoor temperature and should be increased.

If we compare the heat consumption in the two blocks and adjust the registration with the difference in the indoor temperature of 2 ºC we find the adjustment value to about 13%. This is based on the heating period from late September to mid May of about 245 days and the registered 3932 degree days. The two degrees equals 490 degree days.

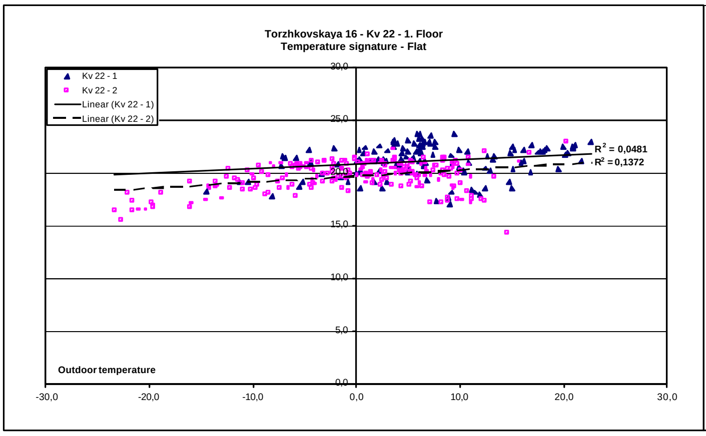
The registered difference in energy consumption is 38% of the neighbouring house. When we adjust the consumption with the difference in the indoor temperature we find that the energy consumption is approximately 33% of the basic consumption. This means adjusted energy saving of about 67%.

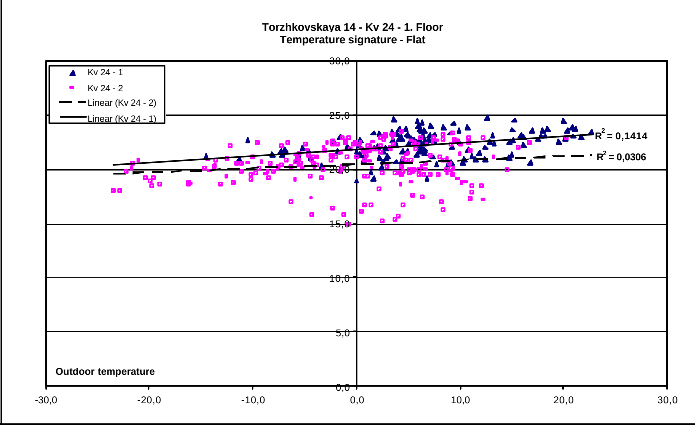
4.5.2 Results from loggers placed at pipes

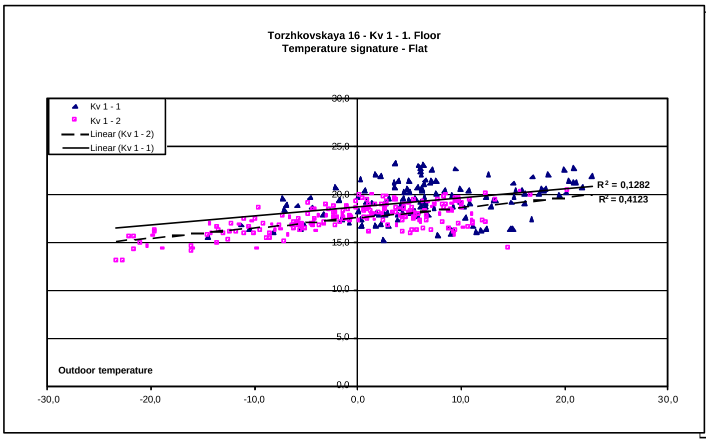
Registrations from the secondary supply pipe in the two buildings showed higher supply temperatures for Torzhkovskaya 16 than for Torzhkovskaya 14. Especially for Torzhkovskaya 16 the temperatures in the secondary supply pipe clearly reflected the outdoor temperature. The higher secondary supply temperatures were a natural result of the lower flow and the same difference pressure. This situation of course increased the capacity of the radiators. The lower flow and the increased secondary supply temperature will benefit the district heating supplier with lower operation costs.

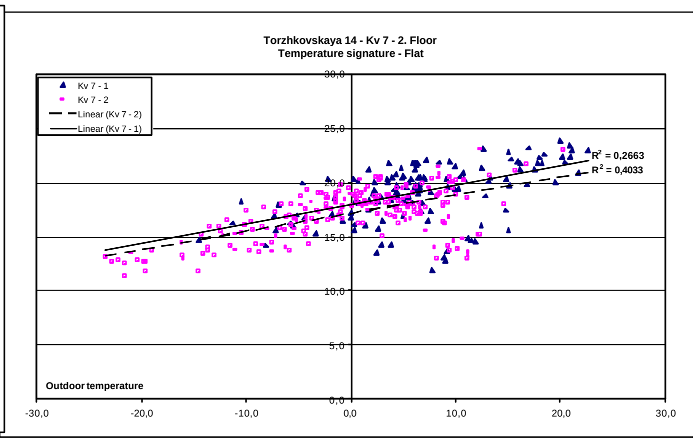
Signatures – Temperatures in flats

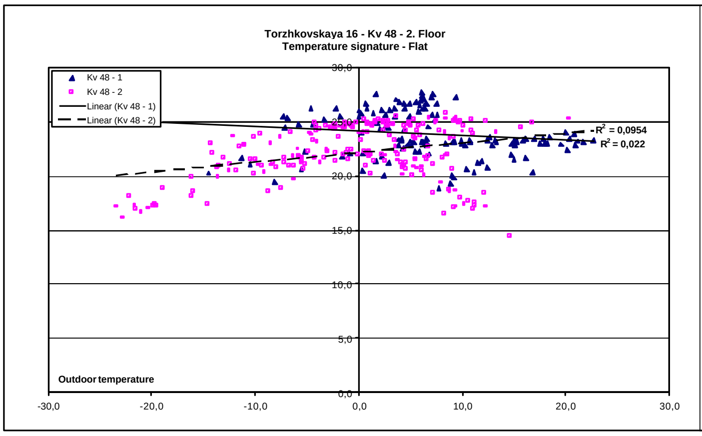
Torzhlovskaya 16 | Torzhlovskaya 14

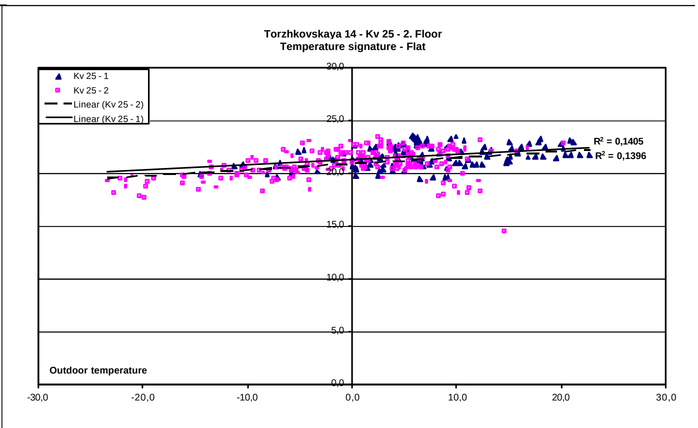


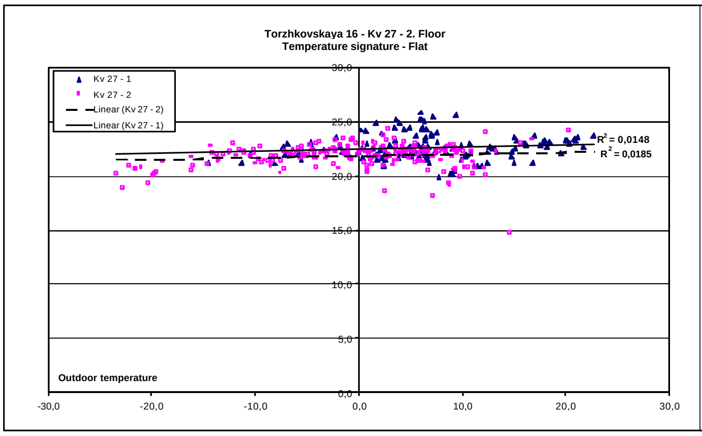


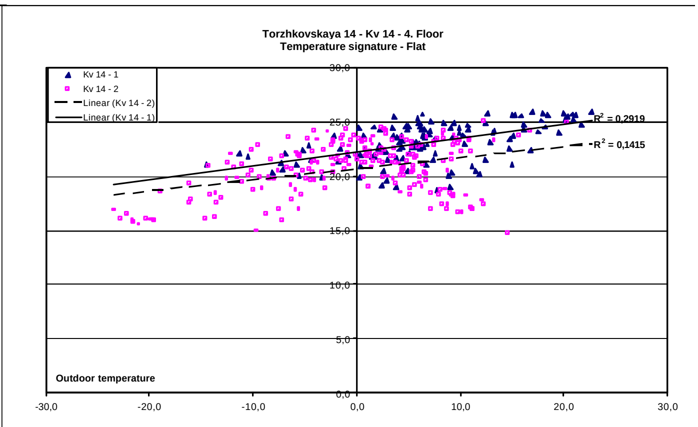








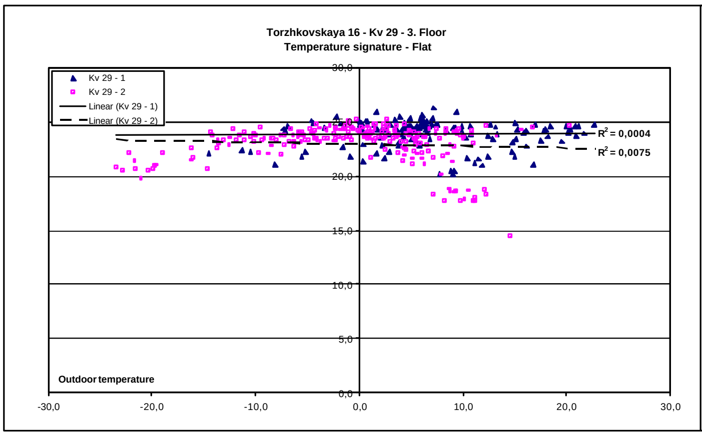


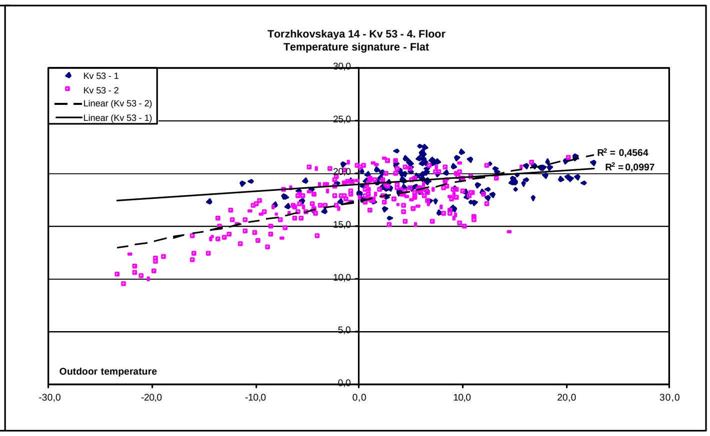


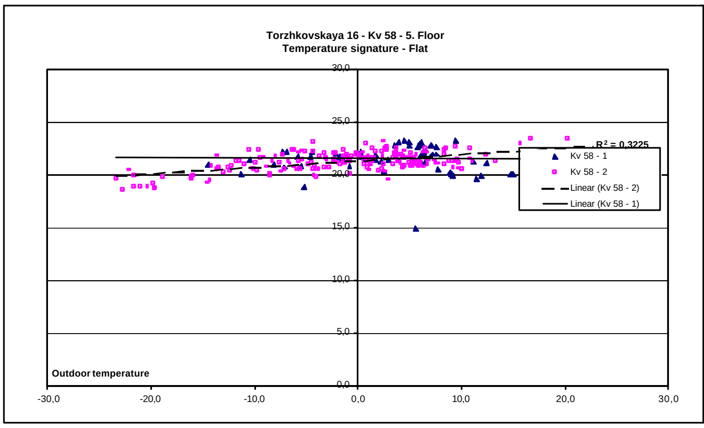
Signatures – Temperatures in flats

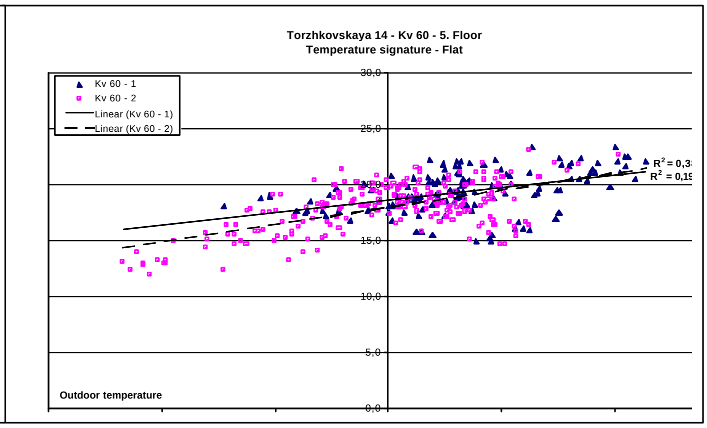
Torzhlovskaya 16

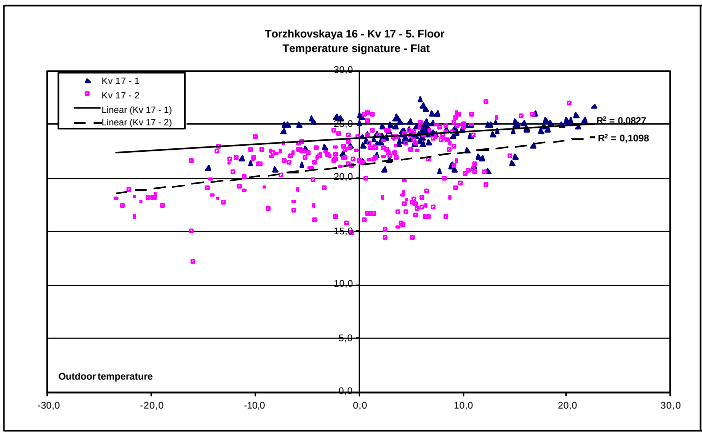
Torzhlovskaya 14

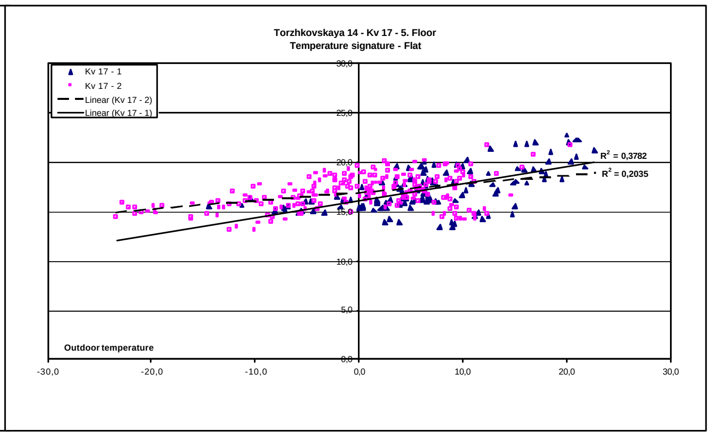


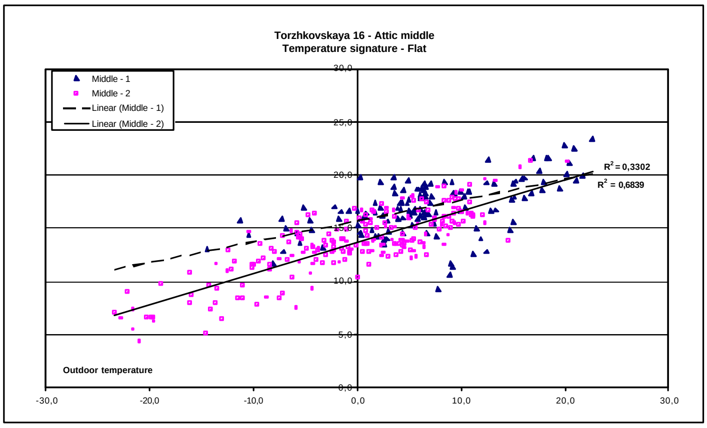








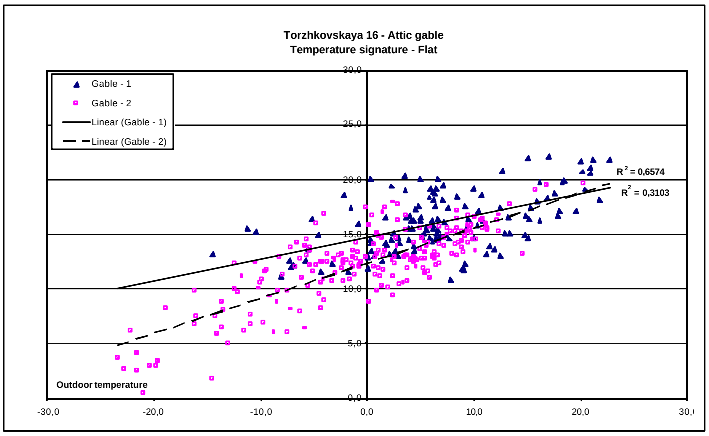




Signatures – Temperatures in flats

Torzhlovskaya 16

Torzhlovskaya 14

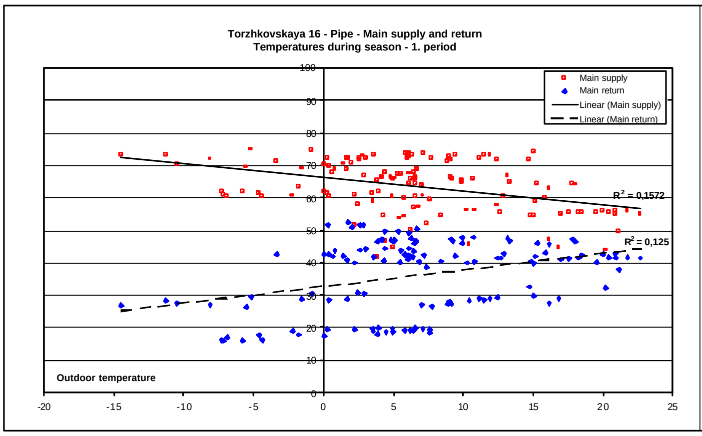


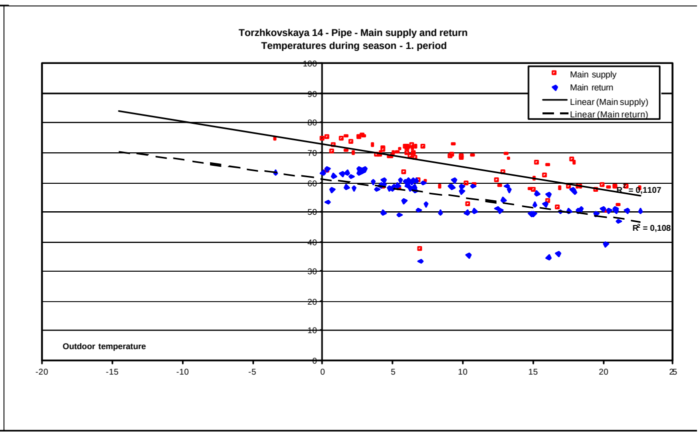
Appendix

Comparison of temperatures based on data from loggers

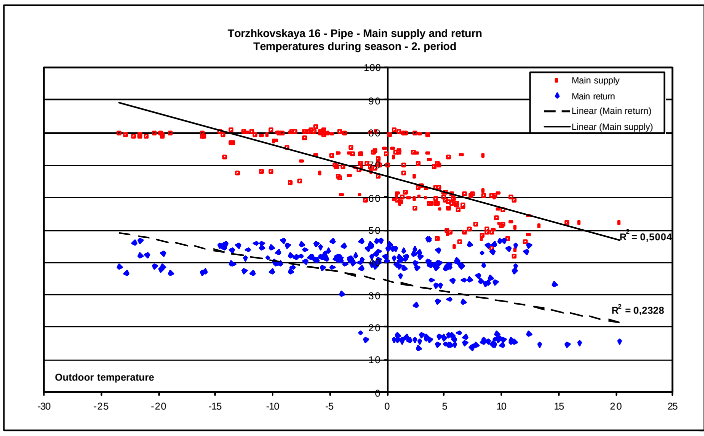
Torzhlovskaya 16 | Torzhlovskaya 14

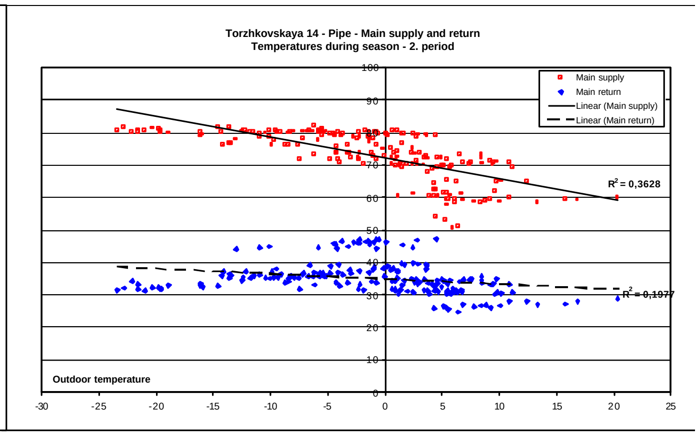
Temperature signature – Main supply and return 1st period (2001-2002)



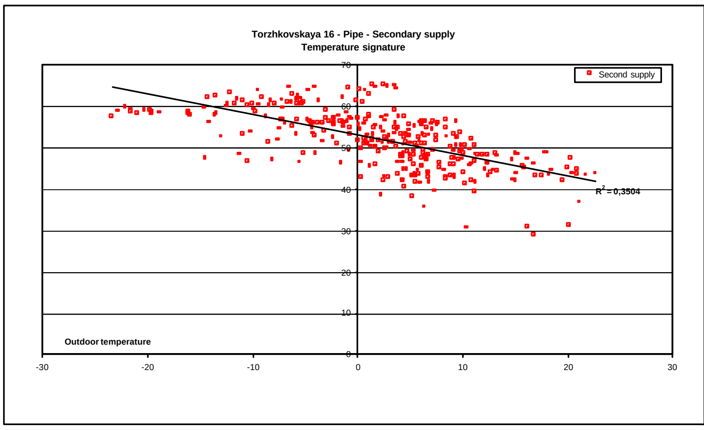


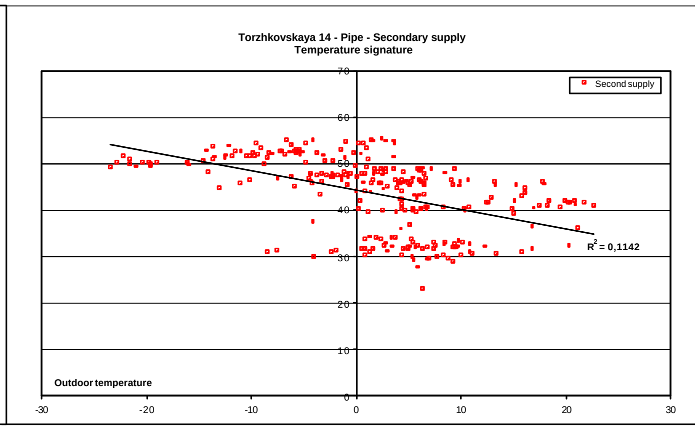
Temperature signature – Main supply and return 2nd period (2002-2003)





Temperature signature – Secondary supply



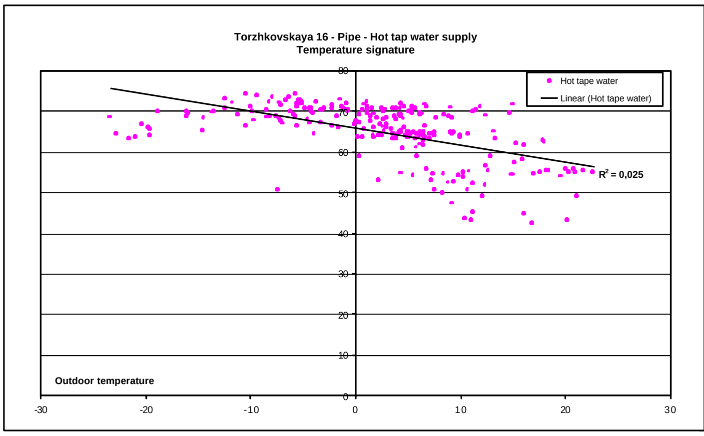


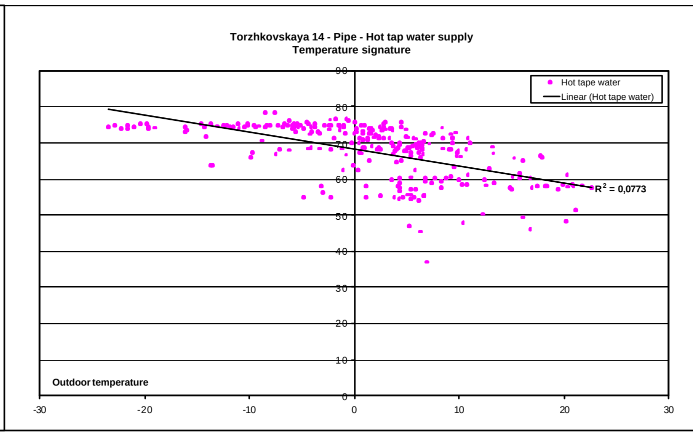
Appendix

Comparison of temperatures based on data from loggers

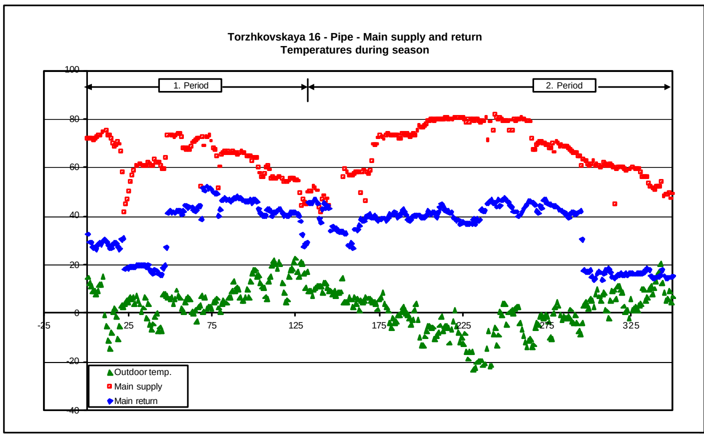
Torzhlovskaya 16 | Torzhlovskaya 14

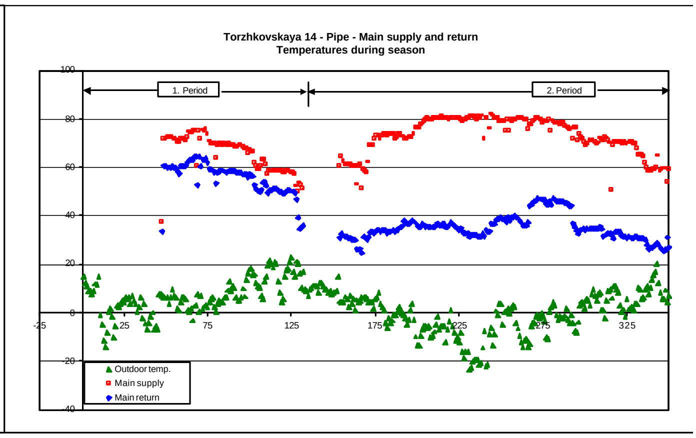
Temperature signature – Hot water supply



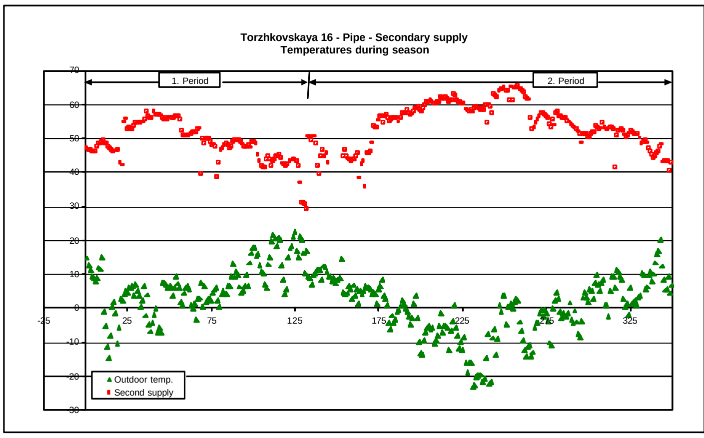


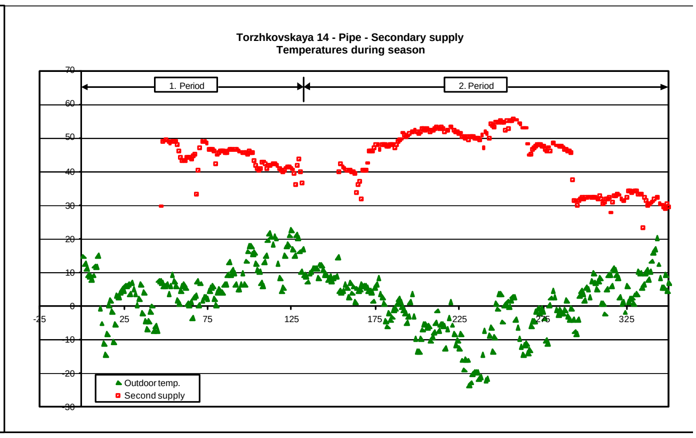
Temperatures during season – Main supply and return





Temperatures during season – Secondary supply





Appendix

Comparison of temperatures based on data from loggers

<u>Torzhlovskaya 16</u> | <u>Torzhlovskaya 14</u>

Temperatures during season – Hot water supply